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Sofia, 18/09/ 1996

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Dear Dr. McIver,

I am sending you my interim report "Investigations of substances of Te-123m and repetition of Alpatov-Davidov's experiments" (5 p. follow).

Please, let me know if it is in a good conditions.

Thank you.

Sincerely yours,

(prof. Pavel Simeonov Kamenov)

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13. ABSTRACT (Maximum 200 words)

This report results from a contract tasking Sofia University, Faculty of Physics as follows: The contractor will synthesize improved 125mte samples for use in gamma emission experiments as described in his proposal.

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INTERIM REPORT

Title:

INVESTIGATIONS OF SUBSTANCES OF 125m-Te AND REPETITION OF ALPATOV-DAVIDOV'S EXPERIMENTS.

Author: P. S. Kamenov

SHORT DESCRIPTION OF THE PRINCIPAL WORKS FOR THIS PROPOSAL.

In 1985 Kamenov and Bonchev [1] suggested that stimulated emission of gamma-rays is possible if the following conditions are fulfilled: (*i*) there exists a gamma-ray transition in a nucleus between two excited states *m* (high) and n (low) and the lifetime of the upper level is much greater than the lifetime of the lower level, $\tau_m >> \tau_n$, $\tau_n < 10^{-9}$s, (*ii*) gamma-ray energy is less than 150 keV. These conditions make possible the population inversion of the levels $N_m/N_n = \tau_m/\tau_n$ and the cross section for stimulated emission $\sigma_{\gamma\gamma}$ to be sufficiently large. The authors [1] proposed for this experiments the isomer ^{125m}Te.

In several works a Russian group reported the observation of pairs of gamma-rays, i.e. stimulated emission with the above isotope [2,3]. *These experiments were misinterpreted because the cross-section for the stimulated emission* $\sigma_{\gamma\gamma}$ *has been calculated with great error which was identified by us* [5,6]. The experimental cross-section is very big (σ_{exp}=8.4x10^{-19}cm^2) and it is in drastic contradiction with the predicted in [4] (the discrepancy is more than 10^{18} times).

Kamenov [5-7] calculated the *correct cross-sections* for interaction and showed that the calculated value coincides with the experimental values obtained by the Soviet researchers [2,3].

Kamenov and Petrakiev [8] showed that the amplification M of the stimulated radiation along the axis of a cylinder with length *l* and diameter *d* ($l >> d$<0.1 cm) can be tens of orders of magnitude, and the power of the gamma-radiation along the axis - kW. Kamenov and Petrakiev [9] showed that the width of the amplified line is less than the natural one (of the corresponding transition), and that effect can be measured in experiment. They also calculated that the critical concentration for ^{125m}Te (for

gamma-ray generation) is $Ko \geq n/n_o = 0.0307$, here n is the number of excited nuclei and n_o is the number of all nuclei (excited, ground state, impurities). Again in [8] the authors show that if ^{124}Te is irradiated with thermal neutrons in a reactor with a neutron flux $\Phi \geq (1.2 - 2).10^{15}$ n/cm^{2}s for a period sufficient for reaching the maximum activity, then the concentration of the excited nuclei will be approximately the critical one and the generation of the gamma-radiation is expected to increase exponentially with l (Fig.4.)[7]. If the thermal neutron flux is smaller, enrichment of the exited nuclei will be necessary ($Ko > 0.0307$).

IN SPITE OF THIS NEW RESULTS AND DEVELOPMENTS some scientists (for instance Baldwin and Solem [10]) continue to think that the cross-section for stimulated emission $\sigma_{\gamma\gamma}$ is very small and the experimental results of Alpatov-Davidov's group [2,3] are fallacious. Kamenov showed [11] that the work of Baldwin and Solem [10] is not correct and that the cross-section for stimulated emission ($\sigma_{\gamma\gamma}$) is comparable with the cross-section for Moessbauer effect.

The conclusion from the experiments and the calculations in the cited papers is that the construction of a gamma-ray laser is a *technical and comparatively inexpensive task*. The energy storage in the active element of $^{125m}TeBe$ is more than 10^7 J/g. The applications of such a device with monochromatic and concentrated in one direction radiation are obvious and we do not discuss them in the present report (some applications are mentioned in [12]).

SOME NECESSARY ANALYSES AND EXPLANATIONS.

We have no doubts about Russian experiments [2,3] and about our calculations of the cross-section for stimulated emission [5-7], but we understand very well that it is necessary to repeat these experiments. The repetitions can be done with other suitable isomers such as 119m-Sn, 123m-Te and so on.
We think that the crucial point in this experiment must be searching the substances which have a *great concentration* of the

excited nuclei and a *great Moessbauer recoilless factor*. Only recoilless gamma-quanta can produce stimulated emission while the intensity of the double energy peak depends of the concentration. The following considerations must be taken into account:

1. 125m-Te (and 119m-Sn) have transitions (35 keV) (and 24 keV) which are Moessbauer ones and the effect of Moessbauer was observed in different substances. This is very important for us because by studying the recoilless factor f_m for the effect of Moessbauer one can calculate the recoilless factor for stimulated emission f_s.

2. The cross-section for excitation of 119m-Sn (with thermal neutrons) is hundred times smaller than for 125m-Te and the necessary concentration is difficult to reach. Therefore, 119m-Sn must be studied only with the effect of Moessbauer and after reaching the necessary parameters enrichment of the excited nuclei will be obligatory.

3. Alpatov-Davidov's group has not reported such Moessbauer experiments [2,3].

4. For the substance BeTe the expected value of Debye temperature T_d is $T_d > 400$ K and the recoilless factor for the effect of Moessbauer must be $f_m \approx 0.75 - 0.8$ at the temperature of liquid He.

5. If T_d and f_m have these values, the recoilless factor for stimulated emission must be $f_s \approx 0.1$, which is the value used by Alpatov-Davidov's group [2,3].

6. In the stimulated emission experiments (where double energy peak (2x110 keV) is observed [2,3]), only the quantity $(\sigma_{\gamma\gamma} f_s)$ can be found. So, it is necessary to know f_s which can be determined from the effect of Moessbauer f_m.

7. All Moessbauer experiments can be done with natural Te. For stimulated emission experiments enriched (~95 %) 124-Te is inevitable.

As it is seen, these experiments are extensive and interdisciplinary ones and can be performed by a big team of different specialists. We have begun such a work with French scientists from CEA, CENTRE D'ETUDE BRUYERES LE CHATEL, FRANCE.

SHORT PLAN OF WORKS

Natural Te:

1. Preparation of the substance BeTe: a) with heating of the mixed 1:1 Be and Te (like the Russian experiment [2,3]); b) with mechanic-chemical synthesis in a mill; (both from natural Te).
2. Preparation of sources and absorbers for Moessbauer effect.
3. Preparation of Moessbauer vibrator for measuring at zero velocity (resonant absorption) and high velocity (not resonant absorption).
4. Preparation of a cryostat for liquid nitrogen.
5. A Cryostat for temperature of liquid helium.
6. A planar detector with efficiency $\varepsilon \approx 0.8$.
7. Spectrometric equipment.
8. Irradiation of the sources with thermal neutrons.
9. Measurements with natural sources: a) with vibration and without vibration; b) with self-absorption at different temperatures.
10. Determination of fm and calculations of fs.

Enriched ($\approx$ 95 %) 124-Te:

If the results of measurements are positive, the above equipment and works will be necessary.

EXECUTION OF THE PLAN.

For Phase I we have completed the following items: 1.b), 2 - 4, 6, 7.

The work continues.

Supplement:

A list of references.

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